REMARKS

Summary of Amendments

The specification has been amended, in the first paragraph of the "Background Art" section, to correct a translation blunder in the first sentence of that paragraph. The error is so glaring that its correction is supported by common knowledge, and thus entry of the correction is respectfully requested.

Claims 1 through 3 have been amended to incorporate the limitations of claim 5. Claims 1-3 have also been amended, as has claim 6, for editorial clarity and to address the indefiniteness issues raised by the Office. Claim 5 has been canceled, since it would otherwise be redundant over amended claims 1-3.

Claims 1-4 and 6 are pending before the Examiner.

Claim Rejections – 35 U.S.C. § 112

Claims 1-4 and 6 were rejected for indefiniteness in the recitation of a lower limit on *Li* and *N* concentrations, and of upper limits on *Li* + *N* dose and sheet resistance.

To address these rejections, the phrase "10 ppm or more" has been amended to "at least 10 ppm" in each instance in which the phrase appears in claims 1-3 and 6, while the phrases "5.0×10^{15} cm^{-2} or less" and "10^7 Ω/□ or less" in claims 3 and 6 respectively have been amended to "less than or equal to 5.0×10^{15} cm^{-2} " and "not greater than 10^7 Ω/□."

It is believed that these revisions have rendered unequivocal the recitation of the limits in question.

Claim Rejections – 35 U.S.C. § 103

Claims 1-6; Zaitsev (in view of routine skill in art)

Claims 1-6 were rejected as being unpatentable over a single non-patent reference, *Optical Properties of Diamond: A Data Handbook* by A. M. Zaitsev, in view of alleged routine skill in the art. Each of claims 1-6 is rejected over the Zaitsev paper according to the following pattern.

(1) Statement that *Zaitsev* teaches implanting Li and N into diamond, and annealing the resulting Li- and N-incorporating diamond;

(2) Acknowledgement that *Zaitsev* does not teach the detailed limitations that the claim recites, further to the above-paraphrased statement of what *Zaitsev* is said to disclose;

(3) Statement that *Zaitsev* discloses the general conditions recited in the claim;

(4) Statement that the detailed limitations acknowledged to be absent from *Zaitsev* are merely "optimum or workable ranges" that entail only "routine skill in the art"; and

(5) Acknowledgement that differences between the invention as claimed and the prior art as described should signify differences in properties, but unless such differences are unexpected, the claimed invention is obvious in view of the prior art.

The passage in *Zaitsev* that the Office relies upon in making the rejections is in the description of Fig. 5.107. There *Zaitsev* states that a diamond sample—it is not clear whether the sample is mono- or polycrystalline—is implanted with: N^+ ions at several energies from 30 to 340 keV, to a uniform doping concentration of 10^{20} cm^{-3}; and Li^+ ions at 100 and 200 keV implantation energies, each at a dose of 10^{15} cm^{-2}. In the same passage, *Zaitsev* also states that the sample was annealed at 1400°C for two hours.

The N^+ concentration therein, by a straightforward conversion, appears to be 1780 ppm. And although the text description of Fig. 5.107 in *Zaitsev* is silent as to the Li^+ concentration resulting from the implanting parameters, from the bottom half of the figure itself, it does appear that the Li^+ concentration overlaps the N^+ concentration at a depth range of circa 2000-4000 Å, or roughly 0.2 to 0.4 μm. Because the N^+ concentration stays at 1780 ppm until nearly 4000 Å, throughout most of the depth where the N^+ and Li^+ concentrations overlap, the Li^+ concentration would presumably be at least 10 ppm.

Accordingly, it is acknowledged that i) *Zaitsev* discloses diamond implanted with N^+ and Li^+ at overlapping concentrations of at least 10 ppm in a depth range of roughly 0.2 to 0.4 μm, and ii) *Zaitsev* teaches annealing the diamond at 1400°C.

Nevertheless, in the first place, *Zaitsev* is exclusively concerned with the optical, not electrical, properties of diamond. *Zaitsev*, at least as cited, nowhere discusses the properties of diamond as a semiconductor. In particular, *Zaitsev* never mentions sheet resistance, or even resistivity.

The present invention, in contrast, achieves in monocrystalline diamond an unexpectedly low sheet resistance of not greater than 10^7 Ω/□. In particular, to achieve this property, according to the present invention the implanted Li and N

dopants are electrically activated by <u>annealing the *Li*- and *N*-implanted diamond at a temperature in the range of from 800°C to less than 1800°C, under high-pressure conditions of at least 3 GPa</u>.

By the present amendments, independent method claims 1-3 now each recite a step of annealing the post-implantation diamond (also termed the "diamond incorporating *Li* and *N*") <u>at a temperature in the range of from 800°C to less than 1800°C, under high-pressure conditions of at least 3 GPa</u>.

As noted above under Summary of Amendments, the limitations formerly recited in claim 5, now canceled, have been incorporated into claims 1-3. In rejecting claim 5, the Office states, at the bottom of page 7 and the top of page 8 of the action,

> *Zaitsev* . . . does not teach the temperature in the range of 800°C to less than 1800°C, under high-pressure conditions of 3 GPa or more. However[, with the] *Zaitsev* disclosure for given conditions of the claimed invention, the claim[ed] range is considered to be an obvious matter of finding an optimum workable range for some chosen design requirement utilizing [the] *Zaitsev* method.

Actually, *Zaitsev* does discuss high-pressure, high-temperature treatment of various forms of diamond, but only in terms of the effect of such treatment on the H3 center (optical center having a zero-phonon line at 2.43 eV). In the second paragraph under the caption for Fig. 5.106 of *Zaitsev*, preceding Fig. 5.107—which appears to have been particularly cited by the Office (although the action refers to "page 265," no page numbers whatsoever appear in the copy provided to Applicants by the Office)—*Zaitsev* discusses the work of different researchers, stating variously:

> [T]he relatively strong CL [cathodoluminescence] of the H3 center was excited in low-nitrogen {113} growth sectors of synthetic diamonds grown with an Fe catalyst after high-temperature annealing (up to 2000°C) under high pressure (6 GPa).
> (. . .)
> [The H3 center] is intensively created in polycrystalline sintered diamond compacts by annealing at temperatures above 1300°C under a pressure of 9.5 GPa.
> (. . .)
> In synthetic diamonds, the H3 center may be created by annealing at 1100°C at normal pressure. However, annealing at 1200°C under a pressure of 50 kbar destroys the center.

It should be noted that the H3 center is a *defect* center, composed of two nitrogen atoms about a vacancy; hence any high-pressure, high-temperature processing parameters that would destroy the H3 center would presumably be

counterproductive against the present invention's intentional implantation of diamond with N ions.

Furthermore, from the above quoted statements from *Zaitsev* one must conclude that a skilled person in the art would not know what to expect—in terms of effect on optical properties to begin with, let alone electrical properties—from the different conditions investigated by earlier researchers for sintering and annealing both polycrystalline and synthetic diamond. For example, while annealing at temperatures above 1300°C under a pressure of 9.5 GPa "intensively creates" H3 centers, annealing at 1200°C under a pressure of 50 kbar (5.0 GPa) "destroys the center[s]." Thus, it is respectfully submitted that given the unpredictable state of the art, discovering optimal or workable ranges involves more than "routine skill in the art"; indeed, according to *Zaitsev* one must conclude that expected results have yet to be defined.

What is more, the foregoing statements from *Zaitsev* merely underscore that, as noted earlier, *Zaitsev* is exclusively concerned with the optical, not electrical, properties of diamond. Claims 1-3 are directed to a method of manufacturing *n*-type monocrystalline, *Li*- and *N*-implanted diamond having the unexpected property recited in claim 6, i.e., a sheet resistance of not greater than 10^7 $\Omega/\square$. This diamond is achieved by the method as now recited in any of claims 1 through 3.

As quoted earlier, the Office alleged that "The claim[ed] range is considered to be an obvious mater of finding an optimum workable range for some chosen design requirement utilizing [the] *Zaitsev* method." Yet if that is the case, then the Office should demonstrate how sheet resistance is a "chosen design requirement" that would lead a person skilled in the art to optimize some result-effective variable(s) according to *Zaitsev* to arrive at the present invention.

That is, nothing in *Zaitsev* discloses or teaches or suggests annealing *n*-type monocrystalline, *Li*- and *N*-implanted diamond in such a manner as to effect a sheet-resistance result in the diamond. Hence, a person skilled in the art seeking, as a chosen design requirement, to optimize the sheet resistance of diamond as a semiconductor would turn to *Zaitsev* in vain for any guidance whatsoever as to how to achieve such a requirement, let alone any result-effective variables for discovering optimal workable ranges to do so.

It is respectfully submitted that for the foregoing reasons independent claims 1-3 and 6 should be held allowable, as should then be claim 4 which depends directly from claim 3.

Accordingly, Applicant courteously urges that this application is in condition for allowance. Reconsideration and withdrawal of the rejections is requested. Favorable action by the Examiner at an early date is solicited.

Respectfully submitted,

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/James Judge/

James W. Judge
Registration No. 42,701

JUDGE & MURAKAMI IP ASSOCIATES
Dojima Building, 7th Floor
6-8 Nishitemma 2-Chome, Kita-ku
Osaka-shi 530-0047
JAPAN

Telephone: **305-938-7119**
Voicemail/Fax: **703-997-4565**